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Geochemical and Sr-Nd-Pb Isotopic Constraints on the Origin and Magmatic Evolution of Quaternary Lavas of Sakurajima Volcano, Southern Kyushu Island, Japan

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We present the results of a detailed petrogenetic study employing newly determined whole-rock major and trace element geochemical analyses and Sr-Nd-Pb isotopic compositions of andesitic and dacitic Quaternary lavas of Sakurajima volcano, a post-caldera volcano situated within the Aira caldera of Japan. Similar geochemical and isotopic investigations are also carried out on basaltic rocks from pre-caldera stage and monogenetic volcanoes from near Sakurajima volcano. Quaternary lavas of Sakurajima volcano analyzed in this study are classified as porphyritic andesites or dacites that contain a mineral assemblage of orthopyroxene, clinopyroxene, and plagioclase, with or without olivine, in a groundmass exhibiting either hyalo-ophitic or hyalopilitic textures. The trace element characteristics of these samples are similar to those of typical island arc magmas, showing clear evidence of Nb depletion along with enrichments in Rb, K, and Pb, which suggests the addition of aqueous fluids to the mantle wedge during melt generation. The Sr, Nd, and Pb isotopic compositions plot close to a mixing curve between MORB-type mantle and sediments of the Philippine Sea Plate, but displaced a bit towards more radiogenic compositions. Plots of Zr versus Nb concentration in these lavas yield a linear trend that falls on a compositional mixing line between the values for mid-ocean ridge basalt (MORB) and average continental crust. Collectively, these observations indicate that the primary source magmas for the Quaternary lavas of Sakurajima volcano were initially generated by partial melting of MORB-type mantle wedge that had already been hydrated by fluids derived from the subducting Philippine Sea Plate. The additional contribution of significant amounts of crustal material during magma evolution is also evident from the Zr/Nb ratios and Sr-Nd-Pb isotopic compositions of the analyzed andesites and dacites of Sakurajima lava samples. From the mixing relation of Sr-Nd-Pb isotopic compositions, it is suggested that the sedimentary rocks of Shimanto Group can be a source of the crustal materials. Although most of the major element oxide compositions of these lavas show a single linear trend on each of the Harker diagrams, two different trends are clearly discernible on each of the P_2O_5, and TiO_2 versus silica variation diagrams, and are subdivided into low-P and high-P geochemical groups. These two groups can also be distinguished when comparing their P_2O_5 and TiO_2 contents and $^{87}Sr/^{86}Sr$ ratios, relative to their phenocrystic plagioclase modal abundances. The magma mixing trends of Sakurajima lavas, which seem to be extended from mono andesitic end-member to two different deictic end-members, are observed from the relationships of major element contents and $^{87}Sr/^{86}Sr$ ratios. In addition, the low-P versus high-P groups of lavas show distinctive distribution patterns, whereby the high-P lavas are surrounded by low-P lavas in the central to southern parts of the Sakurajima volcano study area. These observations indicate that mixing of andesitic and dacitic magmas played an important role in the genesis of Quaternary lavas of Sakurajima volcano, and that multiple dacitic magma chambers with different geochemical characteristics once existed beneath the Sakurajima area at relatively shallow levels in the crust. From the relations between SiO_2 and Sr isotope ratios, an assimilation and fractional crystallization process is required to originate the andesite and dacite end-members.

Key words: Sakurajima volcano; Aira; Kyushu; caldera; arc magmas; trace elements; Sr-Nd-Pb isotopes

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